Dynamic Voltage and Frequency Management Based on Variable Update Intervals for Frequency Setting

Mehrdad Najibi Mostafa Salehi Ali Afzali Kusha

Massoud Pedram S. Mehdi Fakhraie Hossein Pedram

Presentation given at ICCAD, Nov. 2006

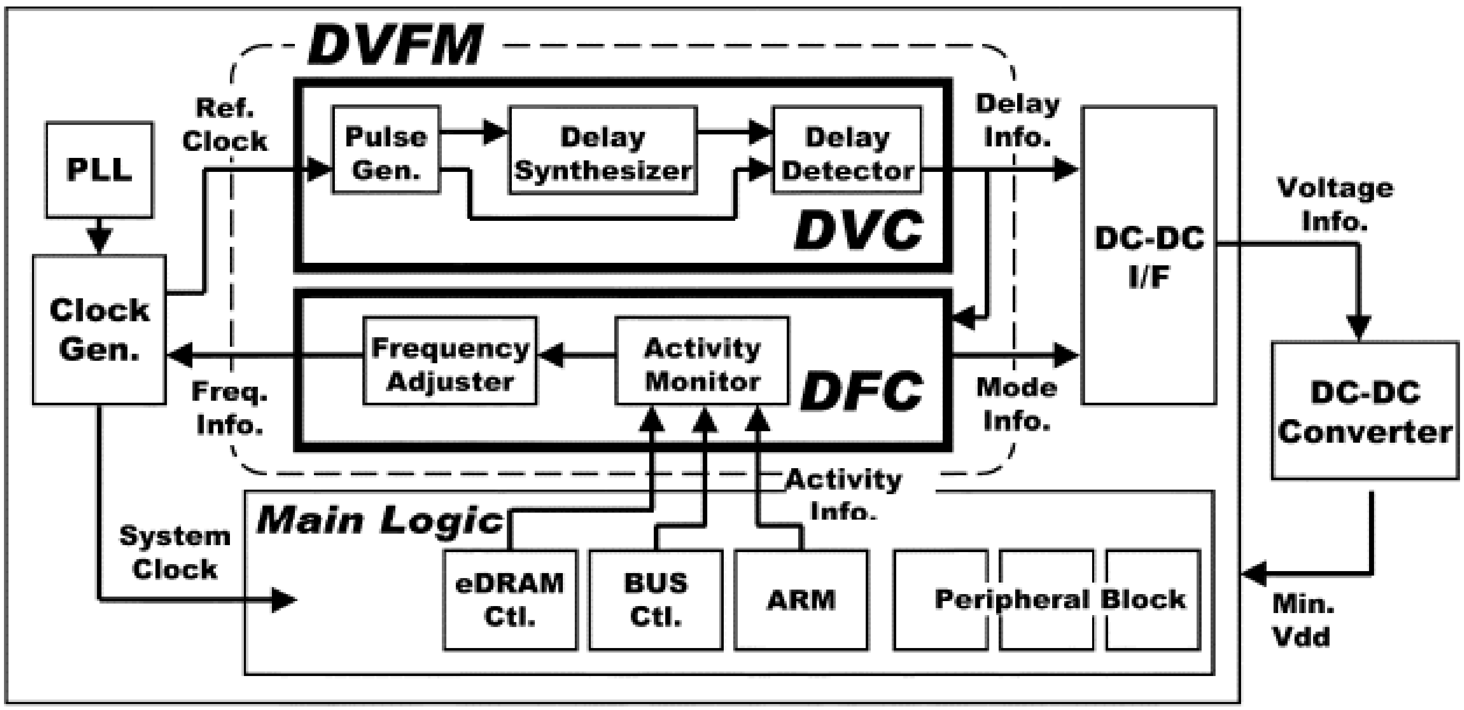
Outline

- Prior Work
- Dynamic voltage and frequency management
- Adaptive frequency scheduling based on an effective deadline
  - Effective deadline prediction
  - Frequency scheduling
  - Underload and overload conditions
- Experimental results

Prior work

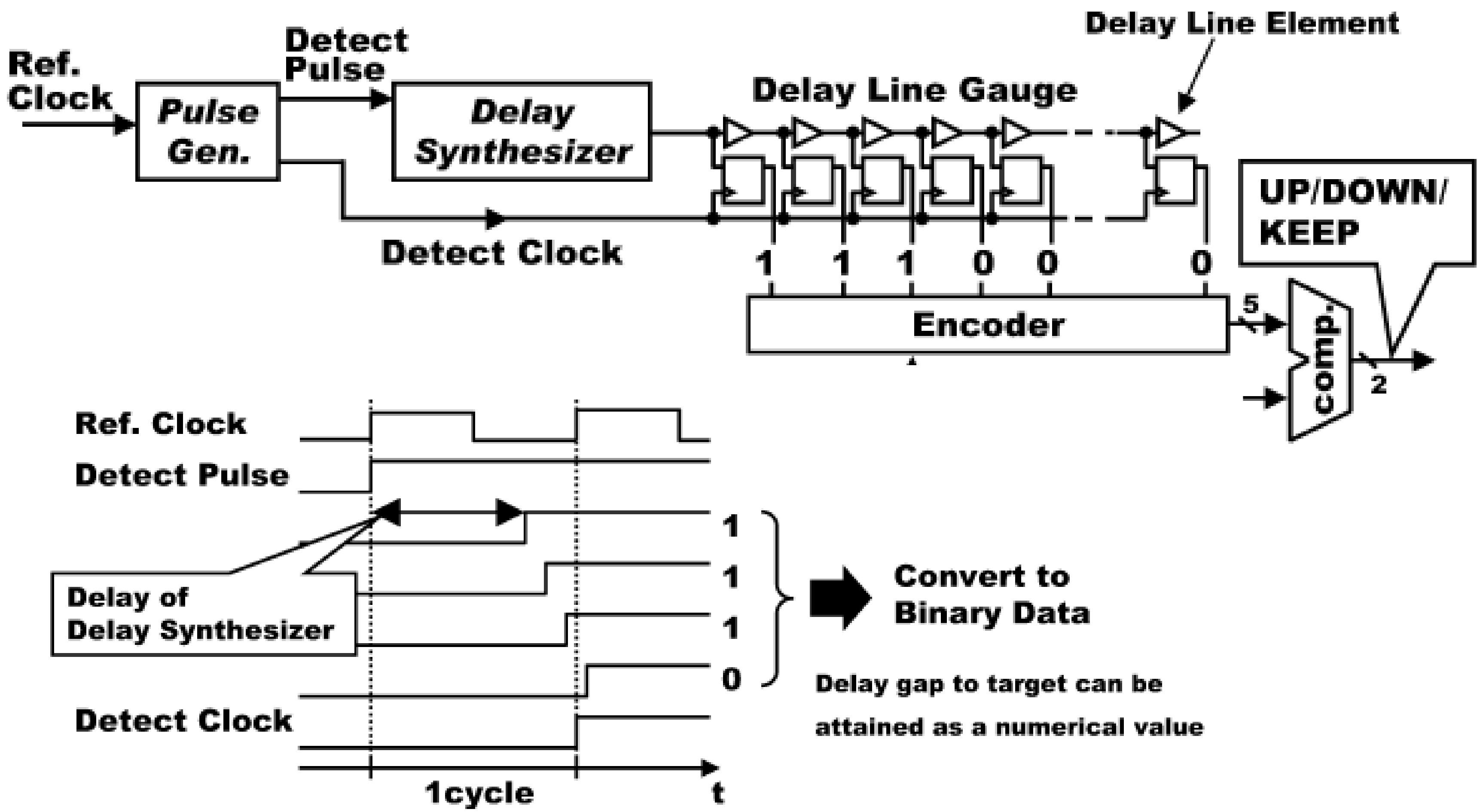
- Commercial processors with DVS capability
- Burd et al, 2000, Arm8 processor core
- Nowka et al, 2002, PowerPC processor
- Flautner and Flynn, 2002, arm9 processor core
- Kihwan et al, 2003-05, StrongArm and Xscale
- …
- Nakai et al, embedded microprocessor

Dynamic Voltage and Frequency Management



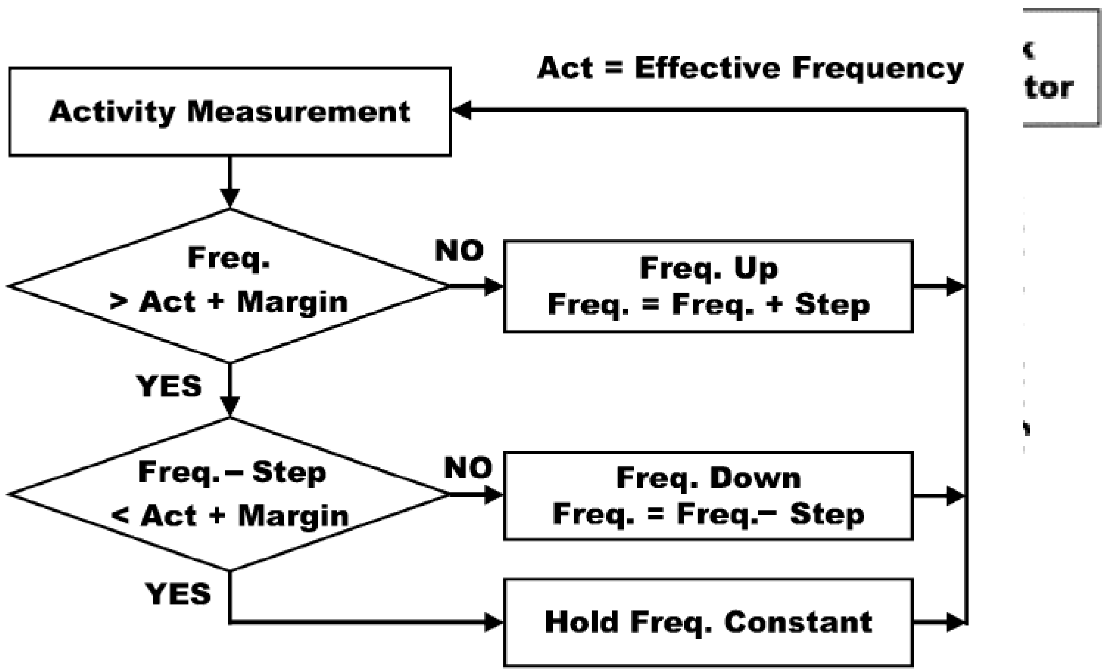
DVFM architecture [Nakai et al, JSSC-05]

Dynamic Voltage Management



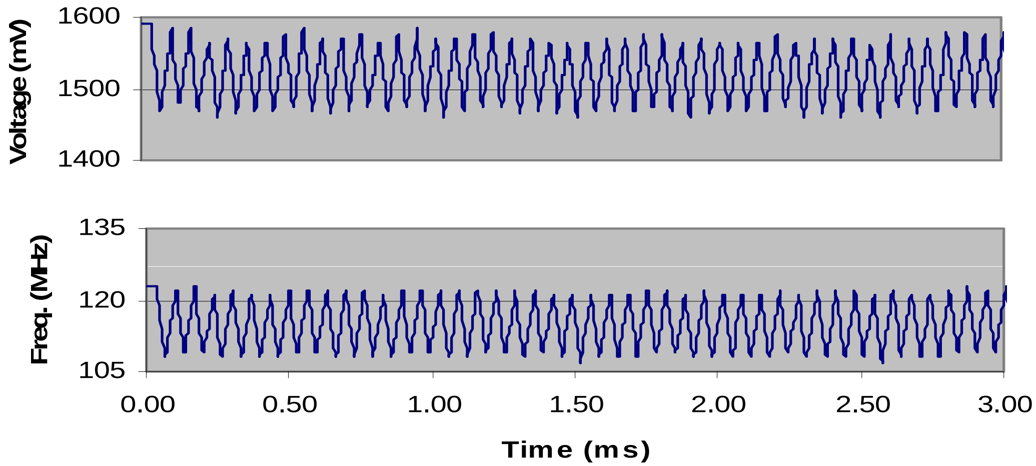
Dynamic Frequency Management

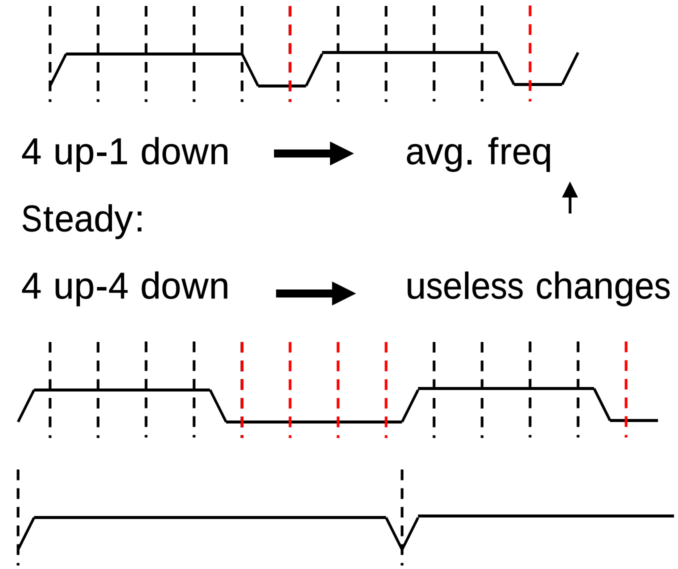
- Frequency scheduling based on fixed interval [Nakai et al, JSSC-05]



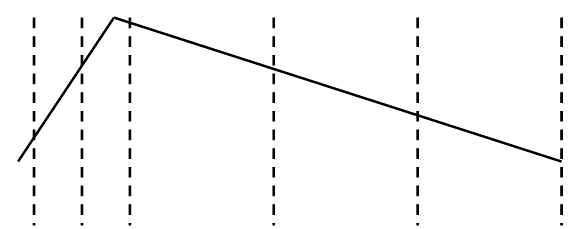
Adaptive Frequency Scheduling Based on an Effective Deadline

- Fixed Interval



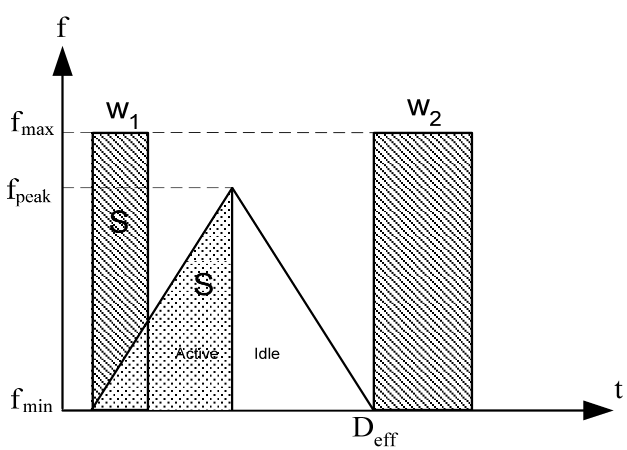


- Adaptive Interval
  - Lower updates
  - Near optimal frequency & voltage



Effective Deadline

- Soft Real Time Application
- Periodic Workloads
- Arrival of the next workload



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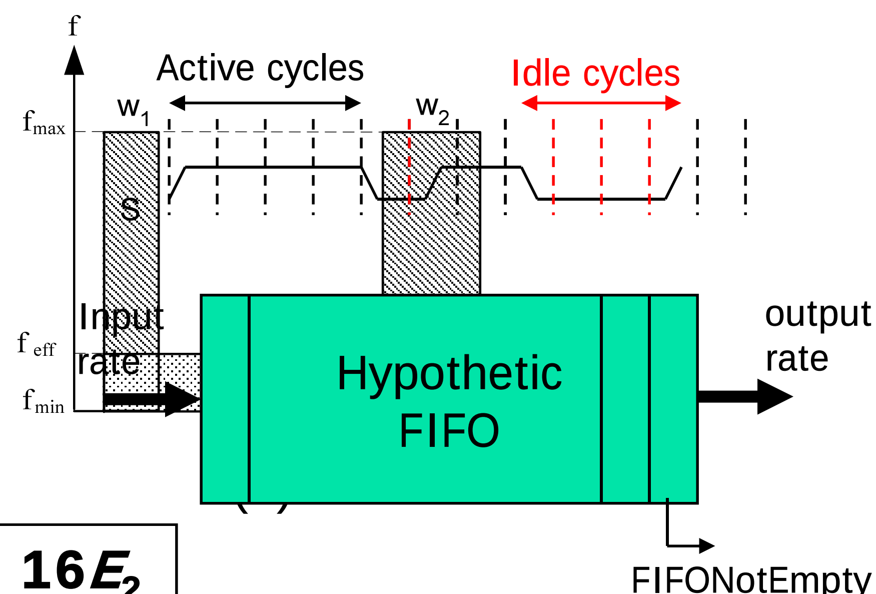
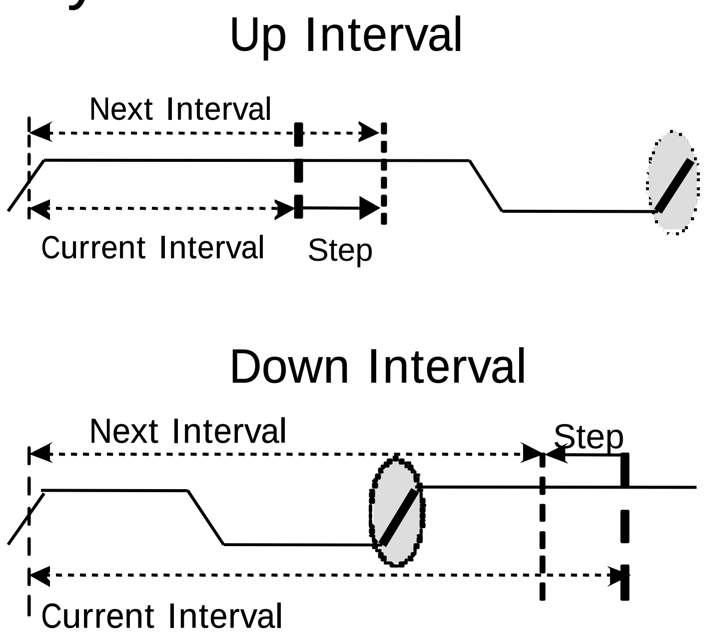


$\boxed{f_{peak} = 4 f_{eff}}$ $\Rightarrow$ $\boxed{E_1 = 16 E_2}$

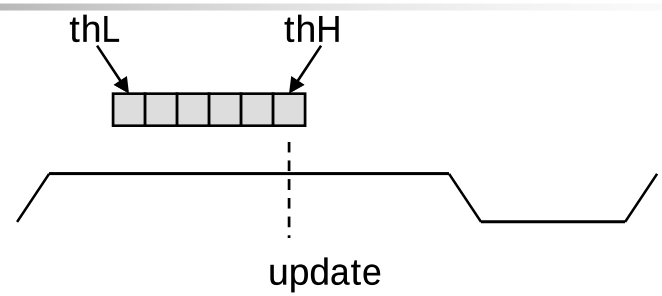
Prediction of the Effective Deadline

- Arrival time of the next workload
  - Reported in terms of system cycles
- Effective Deadline
  - Update the interval
  - Compute the frequency
- Adaptive Adjustment
  - 2 consecutive increases
    - Interval_step * 2
  - 2 consecutive idecreases
    - Interval_step / 2

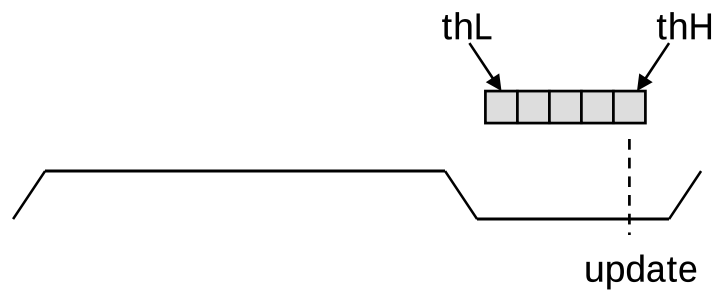


Frequency Adjustment

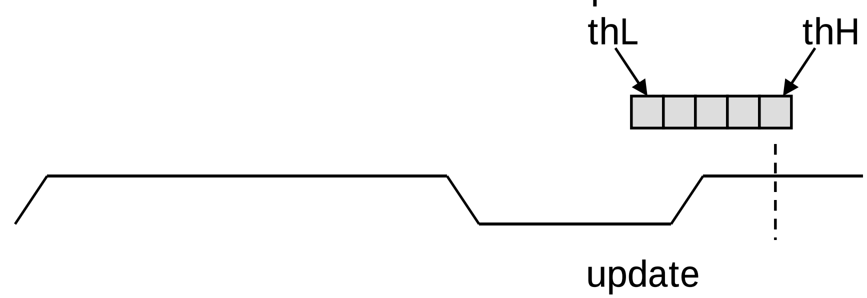
- Frequency Up



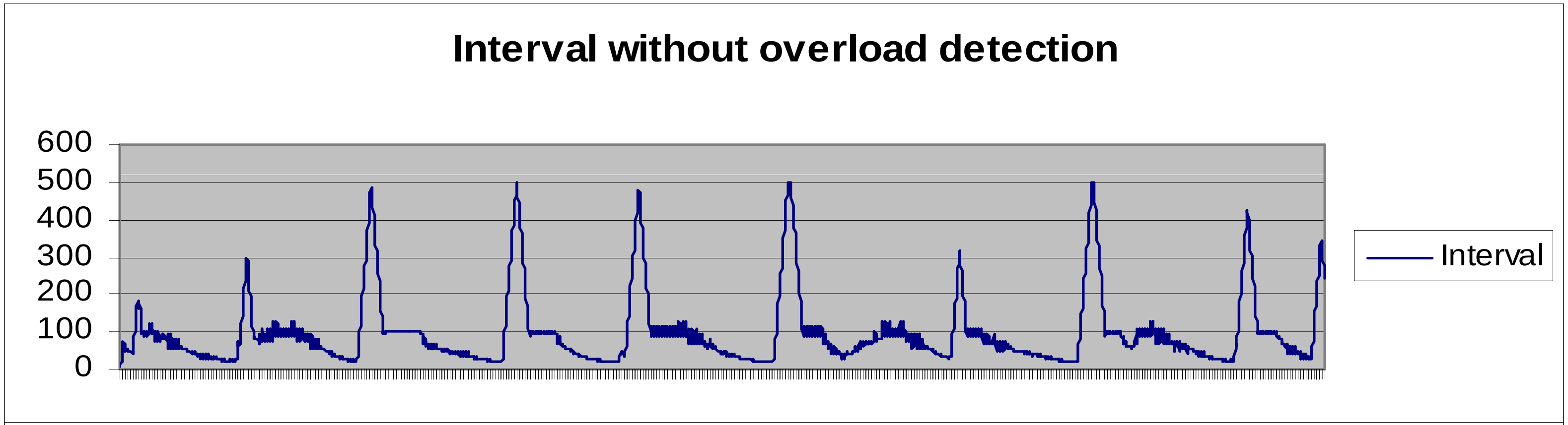
- Frequency Down

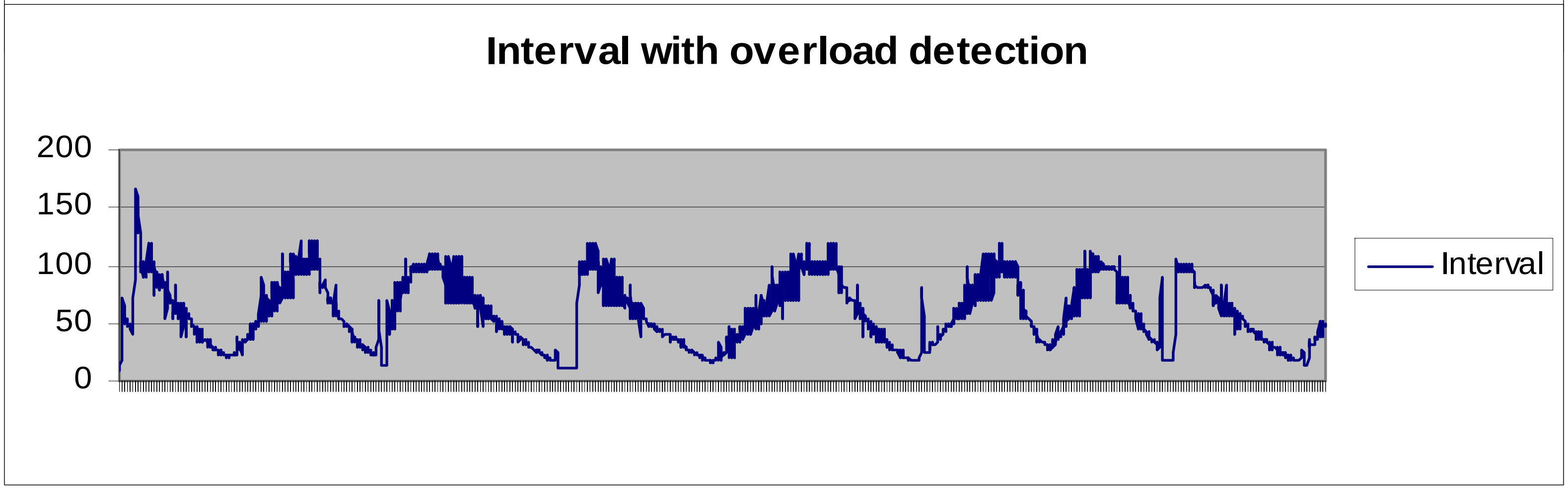


- Frequency Steady

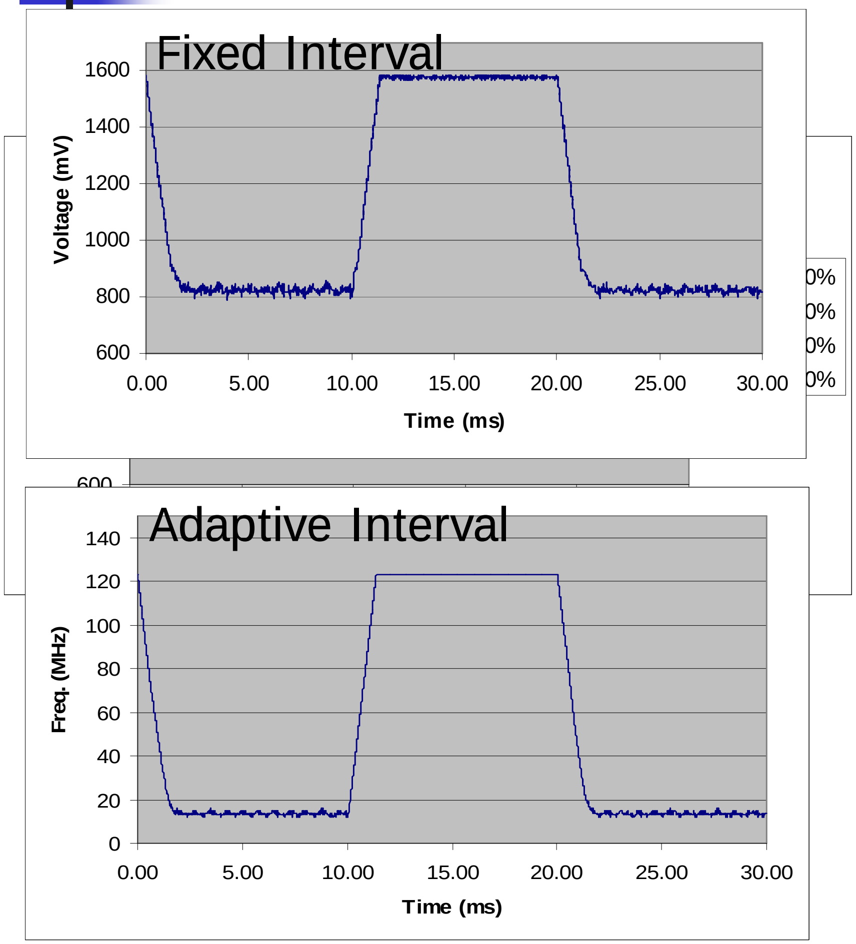


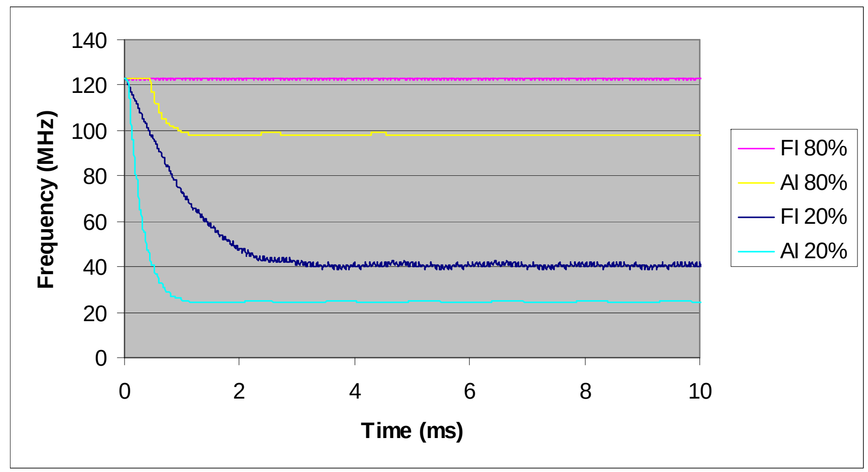
Overload and Underload Conditions





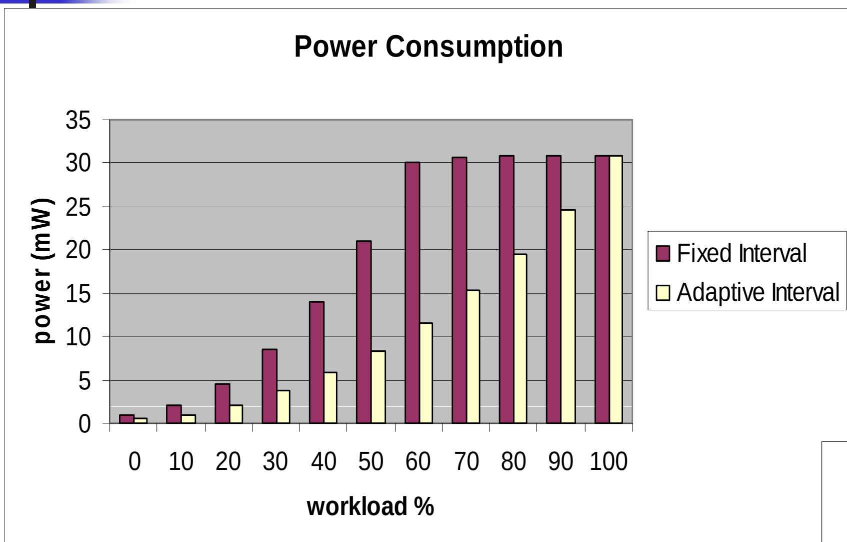
Results (Periodic Workload)





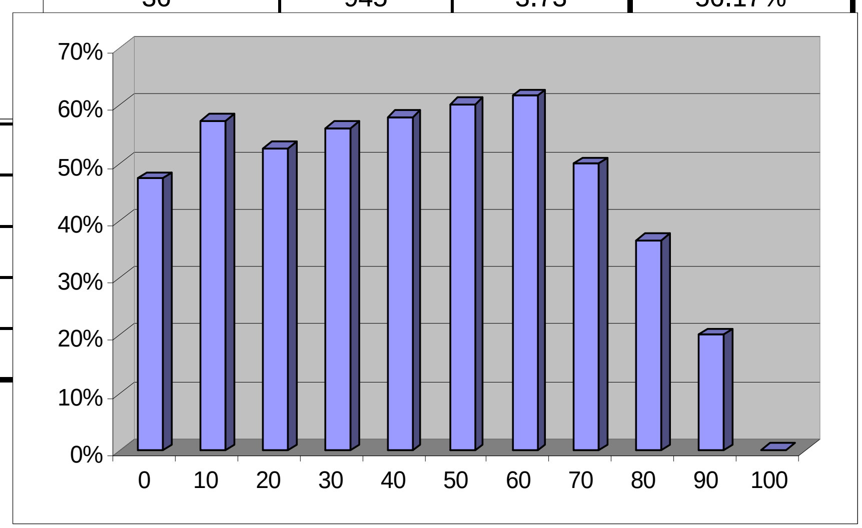
Frequency

Results

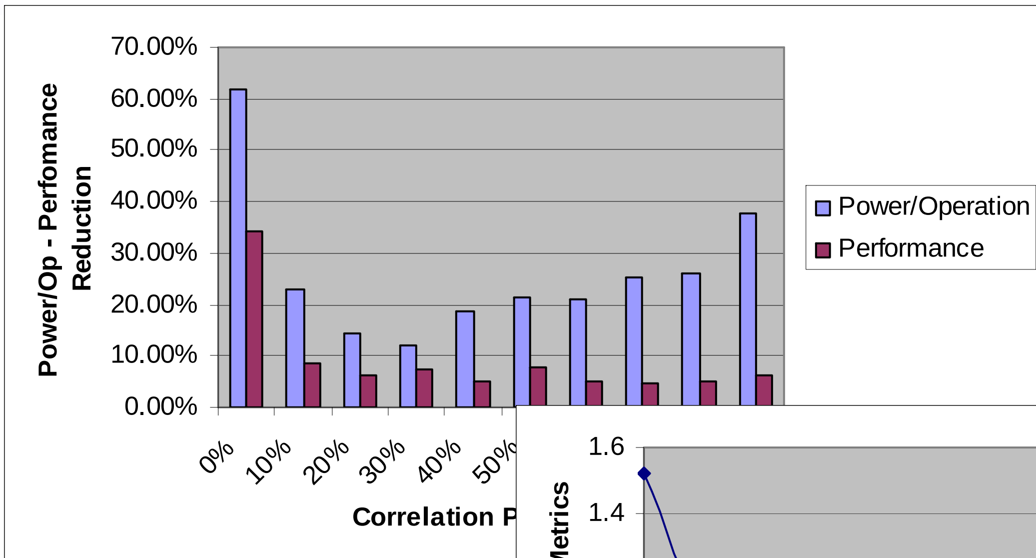


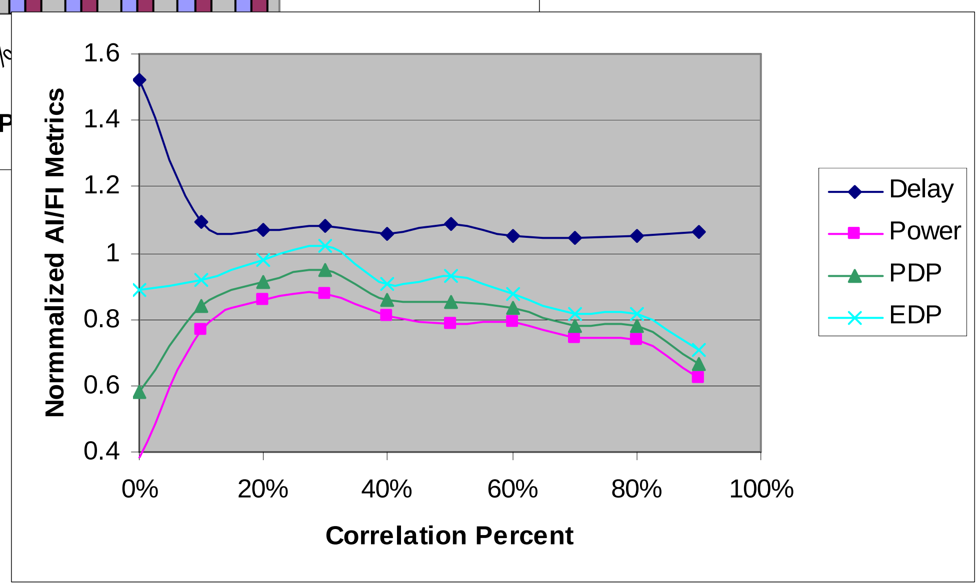
Adaptive Interval			
Frequency (MHz)	V_{DD} (mV)	Power (mW)	Power Reduction
8	600	0.5	47.37%
12	810	0.92	57.41%
25	895	2.17	52.52%
36	945	3.73	56.17%

60%	123	1580	30.02
70%	123	1585	30.59
80%	123	1585	30.77
90%	123	1585	30.89
100%	123	1580	30.92



Results (Correlated Workloads)





Summary

- Presented an efficient adaptive method to perform dynamic voltage and frequency management (DVFM) for minimizing the energy consumption of microprocessor chips
  - Uses adaptive update intervals for optimal frequency and voltage scheduling
  - Rapidly tracks the workload changes so as to meet soft real-time deadlines
  - Utilizes the correlation between consecutive values of the workload for future workload prediction
- Because the frequency and voltage update rates are dynamically set based on variable update interval lengths, voltage fluctuations on the power network are minimized
- The technique leads to power savings of up to 60% for highly correlated workloads compared to DVFM systems based on fixed update intervals.